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METHOD AND DEVICE FOR FASTENING AND ALIGNING A SENSOR

Background Information

The present invention relates to a method and a device for fastening and aligning a sensor, especially a video sensor, on the windshield of a motor vehicle.

Today's motor vehicles are equipped with a plurality of sensors, such as ultrasound sensors or video sensors, in order, for example, to gather information about the surroundings of the motor vehicle. The fastening and aligning of these sensors on the vehicle deserve great importance, in this context, so that the functioning of the sensors may be ensured.

In particular, in motor vehicles, video sensors are used in larger numbers for gathering information on the surroundings. Stereo camera systems, for instance, are used for observing the road space located ahead of the motor vehicle, for object recognition or the measurement of distance from a preceding motor vehicle. In this context, in stereo camera systems two video sensors are used, which are positioned in such a way that they record essentially the same scene.

From German Patent Application 10162652.5 of 12/20/2001, that was not prepublished, methods are known for fastening video sensors in the passenger compartment of a motor vehicle, the sensor being connected via a holding element to a support, especially the inner side of the windshield or the roof. The disadvantage of these methods is that no precise mechanical alignment of the sensors is undertaken. Especially in the case of stereo camera systems, the commonly recorded viewing

angle of the video sensors determines the useful range of the system, since for the evaluation of the image information, overlapping image ranges of both video sensors are needed. The precise mechanical alignment of the video sensors, that is, the setting of the sensor axis, plays a decisive role here for the useful range of the stereo camera system and for the subsequent image processing.

In this context, the sensor axis is regarded as a preferred direction having a view of the measuring process. In a video sensor, the optical axis is equivalent to the sensor axis.

Summary of the Invention

The method described below, for fastening and aligning a sensor via a holding element to a support, has the advantage that a precise alignment of the sensor axis takes place in the nominal direction. In motor vehicles, stereo camera systems are used, for example, to gather information from the surroundings of the motor vehicle, the stereo camera systems being made up of two video sensors, which record essentially the same scene. To evaluate the image information, two overlapping image ranges of the two video sensors are required. The viewing angle of the two video sensors recorded in common defines, in this case, the useful range of the stereo camera system. Because of the precise alignment of the video sensors, the method described here increases in an advantageous manner the useful range of the stereo camera system. In the case of stereo camera systems, the method described and the device makes possible in an advantageous manner the fastening and the precise alignment of the sensor axes of the two video sensors relative to each other. In particular, in an advantageous manner, the setting of the sensor axes of the two video sensors is made possible in such a way that there is squinting of the video sensors. In this

context, the recorded range of the stereo camera system is placed closer to the motor vehicle during installation in the motor vehicle.

By reworking the sensor seating surface, the method described in the following and the device make possible in a particularly advantageous manner the fastening and alignment of at least one sensor, particularly in motor vehicles. In an advantageous manner, the precise alignment of the sensor axis of the at least one sensor is achieved by the determination using measuring techniques of the deviation of the sensor axis from the nominal direction by the surveying of the sensor seating surface and the subsequent reworking.

In one variant of the method, by the use of at least one video sensor, the deviation of the sensor axis from the nominal direction is determined by temporarily not installing the at least one video sensor in the holding element that has not been reworked. By determining the deviation by methods of image processing, such as by calibrating methods in a calibrating field, in this variant, in an especially advantageous manner, the manufacturing tolerances of the support and/or the holding element and/or the sensor seating surface and/or the video sensor are determined, and are compensated for during subsequent reworking.

In one further variant, a carrier is used to which the support is connected. The carrier is a part of the reworking device. The relative position of the support and the holding element with respect to the reworking device is determined by the use of the carrier. The reworking device makes possible the reworking of the sensor seating surface by material-removing reworking methods, preferably milling, drilling and or laser processing. In an especially advantageous manner, in this variant of the method described, the previous measurement of

the deviation of the sensor axis from the nominal direction may be omitted, because the position of the support is directly determined by the connection of the support to the carrier. This makes possible the cost-effective carrying out of the method, since costly measuring units for determining the deviation of the sensor axis from the nominal direction are not necessary.

In an advantageous manner, the method for fastening and aligning various sensor types, such as ultrasound sensors, light-sensitive sensors, video sensors or sensors for electromagnetic radiation may be used. The only assumption is that the sensors have a sensor axis.

It is of advantage that the method is able to be used with convex, concave and/or level surfaces of the support. The method described and the device are especially advantageous for fastening and aligning sensors, preferably video sensors, at the windshield of a motor vehicle. Windshields in motor vehicles have a curved surface. Because of the molding process during manufacturing of the windshield, the curvature demonstrates a wide divergence. The holding element often also has component part tolerances, which result in deviation of the sensor axis from the nominal direction. If there are component part tolerances of the windshield and/or the holding element, the method leads to precise alignment of the sensor axis in the nominal direction in an advantageous manner.

In an advantageous manner, the method may be used with any nominal direction of the sensor axis. The method is particularly suitable if the sensor axis points in the direction of the holding element and the support, or in the opposite direction.

During aligning of the sensor axis to the holding element and the support, the support and/or the holding element have to be transparent to the quantities influencing the sensor. In an advantageous manner, the transparency for the sensor-influencing quantities may also be achieved by material-removing processing methods.

It is also of advantage that the method is able to be applied in conjunction with the use of an adhesion process for fastening the holding element to the support. In an especially advantageous method, the precise alignment of the sensor may be carried out at the same time as the hardening of the adhesive, by reworking the sensor seating surface. This ensures a rapid performance of the fastening of the holding element, and the accurate alignment of the sensor axis may take place at the same time. Especially when the method described is used for fastening video sensors to the inside of the windshield of a motor vehicle, the method described leads to time and cost saving, because the two method steps may be carried out in parallel.

In an advantageous manner, the reworking of the sensor seating surface by various material-removing processing methods, preferably milling, drilling and/or laser processing may take place depending on the type and the properties of the material used for the holding element.

In a particularly advantageous manner, the method described makes possible the aligning of the sensor with respect to its rotation about the sensor axis, by mounting a centering pin receptacle. It is advantageous in this regard that mounting the centering pin receptacle is able to take place during the reworking of the holding element, and that because of that no additional method step is required. This ensures a rapid and cost-effective execution of the method.

In one variation of the method, the accommodation is protected by a cover element for a part of the sensor and/or the sensor antechamber, during the reworking of the sensor seating surface, from the intrusion of chips and other contaminations. Particularly when one is installing video sensors, this leads in an advantageous manner to a better image quality, because the optical path of the images is not disturbed by soiling. In an advantageous way this leads to an extension of the useful life of the sensors, since otherwise, for example, remaining diluted soluble oil is able to lead to corrosion of the sensor and/or the holding element.

The device described below for fastening and aligning a sensor, via a holding element, to a support has the advantage that, during the reworking of the sensor seating surface for the alignment of the sensor in the nominal direction, the accommodation does not have to be changed. This leads to an execution of the method that saves time and costs, since an additional processing of the holding element is not necessary. It is of advantage that the sensor seating surface may be reworked by using an oversize, and the accommodation is larger than the part of the sensor to be accommodated, because of the use of the oversize.

In an advantageous way, the device is designed in such a way that the sensor antechamber is bigger than the angular coverage of the sensor. This makes reworking the sensor's antechamber, while processing the sensor seating surface, unnecessary. This leads to an execution of the method described that saves time and costs.

In one variation of the device, with the sensor installed, the accommodation and the sensor antechamber are sealed from the surroundings by a sealing ring. In particular, when using a

video sensor, this leads in an advantageous manner to a reduction of soiling of the sensor during operation, and thereby to an improvement of the image quality.

Further advantages result from the following description of exemplary embodiments with reference to the figures, and from the dependent claims.

Brief Description of the Drawings

The present invention is explained in detail below, in light of the specific embodiments represented in the drawing. The figures show:

Figure 1 the side view of a device for fastening and aligning a sensor before the reworking of the sensor seating surface,

Figure 2 the top view of a device for fastening and aligning a sensor before the reworking of the sensor seating surface,

Figure 3 the side view of a device for fastening and aligning a sensor after the reworking of the sensor seating surface,

Figure 4 the top view of a device for fastening and aligning a sensor after the reworking of the sensor seating surface,

Figure 5 the side view of a device having a cover element during the reworking using a milling head,

Figure 6 the representation of a device having a centering pin receptacle and a centering pin for aligning the sensor.

Description of Exemplary Embodiments

Figures 1 and 2 show the side view and the top view of a device for fastening and aligning a sensor 13, 23, in the preferred exemplary embodiment a video sensor, before the reworking of sensor seating surface 14, 24. The support 11, 21, on which video sensor 13, 23 is mounted, is the windshield of a motor vehicle. Video sensor 13, 23 is connected via a holding element 12, 22 to the support 11, 21. The connection of video sensor 13, 23 to holding element 12, 22 is made via seating surface 14, 24. Holding element 12, 22, in the preferred exemplary embodiment, has a cylindrical accommodation 16, 26 for a part of video sensor 13, 23. Sensor antechamber 15, 25 is used as a baffle, for the reduction of interfering, stray pick-up light. In Figures 1 and 2, the deviation of sensor axis 18, 28 from the nominal direction 19, 29 is drawn in. In the preferred exemplary embodiment, sensor axis 18, 28 is determined by the optical axis of the video sensor 13, 23. In the preferred exemplary embodiment, nominal direction 19, 29 is determined relatively with respect to the axis of travel of the motor vehicle. Nominal direction 19, 29 is determined with respect to the axis of travel by preferably two angles, such as the vertical pitch angle and the horizontal yaw angle. In the first variant of the preferred exemplary embodiment, for example, nominal direction 19, 29 is parallel to the axis of travel, whereas in the second variant the nominal direction is tilted vertically with respect to the axis of travel.

In the first method step, holding element 12, 22 is connected to support 11, 21, for example, by an adhesion process. In

the preferred exemplary embodiment, holding element 12, 22 is located on the inside of a motor vehicle's windshield. Holding element 12, 22 is fastened close to the inner rearview mirror, so as simultaneously to lie in the wiped area of the windshield and to impair the view of the driver as little as possible.

In a first variant of the preferred exemplary embodiment, after hardening of the adhesive, in the next method step, the deviation of sensor axis 18, 28 from nominal direction 19, 29 is determined by measurement techniques. Preferably, the deviation of sensor axis 18, 28 from the nominal direction 19, 29 is ascertained indirectly by measuring sensor seating surface 14, 24. The measurement is made in this case by optical and/or mechanical measuring methods, such as probes. Alternatively, in a second variant of the preferred exemplary embodiment, temporary installation of video sensor 13, 23 in non-reworked holding element 12 is possible. Preferably, the deviation of sensor axis 18, 28 from the nominal direction 19, 29 is ascertained indirectly by measuring sensor seating surface 14, 24. In this context, the deviation is ascertained by the method of image processing.

In a further variant of the preferred exemplary embodiment, the ascertainment of the deviation of sensor axis 18, 28 from nominal direction 19, 29 by measuring techniques is not necessary. Rather, in this variant, support 11, 21, in the preferred exemplary embodiment the windshield, is fastened using a carrier which is a part of the reworking device. The carrier determines the relative position of support 11, 21 and of holding element 12, 22 with respect to the reworking device. This makes possible a direct reworking, without previous measuring of the deviation of sensor axis 18, 28 from nominal direction 19, 29.

In the following method step, reworking of sensor seating surface 14, 24 is carried out, for instance, on the basis of the deviation ascertained. To rework holding element 12, 22 that has been produced by die-casting technology, various material-removing processing methods, preferably milling, drilling and/or laser processing may be used.

In the last method step, video sensor 13, 23 is connected to holding element 12, 22 via reworked sensor seating surface 14, 24. For the connection, various methods may be used, especially adhesion, screw connection or snap-in techniques. Sealing ring 17, 27 is used for sealing accommodation 16, 26 and sensor antechamber 15, 25 of holding element 12, 22 from the surroundings of the device, particularly during operation of video sensor 13, 23.

Figures 3 and 4 show the side view and the top view of a device for fastening and aligning a sensor 33, 43 after processing sensor seating surface 34, 44. Holding element 32, 42 is connected to support 31, 41. Sensor axis 38, 48 is aligned in nominal direction 39, 49.

In the preferred exemplary embodiment, accommodation 36, 46 is dimensioned by an oversize in such a way that it is able to accommodate the tilting of video sensor 33, 43 after processing of sensor seating surface 34, 44 in diameter and depth. Sensor antechamber 35, 45 is established as a conical opening in such a way that, after the processing of sensor seating surface 34, 44, the angular coverage of video sensor 33, 43 is not restricted by the walls of sensor antechamber 35, 45. Sealing ring 37, 47 makes possible the sealing of the inner space of holding element 32, 42 after processing of sensor seating surface 34, 44, sealing ring 37, 47 being formed in such a way that in the case of tilting of video sensor 33, 43, sealing is ensured. Holding element 32, 42 is

formed in such a way that processing of sensor seating surface 34, 44 is possible when holding element 32, 42 is connected to support 31, 41. At the same time, sensor seating surface 34, 44 is dimensioned in such a way that the function and stability of holding element 32, 42 is not impaired by reworking. This is preferably achieved by fixing an oversize.

Figure 5 shows a variant of the exemplary embodiment. In the reworking of sensor seating surface 56 of holding element 52 which is connected to support 51, a cover element 53 protects the inner space of holding element 52 from the intrusion of chips and/or dirt because of the processing of sensor seating surface 56, particularly by cutting head 55. Seal 54 ensures the waterproof and dirt-tight sealing of the inner space.

Figure 6 shows holding element 61 having a centering pin receptacle 63 and centering pin 64 for aligning sensor 62, a video sensor in the preferred exemplary embodiment, about sensor axis 65. Minimizing the rotation of video sensor 62 about sensor axis 65 is necessary, for example, in order to obtain good image quality. During the reworking of sensor seating surface 66, applying centering pin receptacle 63 is possible in the same method step. The alignment of video sensor 62 is performed by centering pin 64. In one improved embodiment, the use of two or more centering pin receptacles 63 and centering pins 64 is possible.

The method described and the device are not limited to the fastening and alignment of video sensors 13 on the windshield of motor vehicles. The method and the device are suitable for all sensor types that have a sensor axis 18, especially ultrasound sensors, light-sensitive sensors, video sensors and/or sensors for electromagnetic radiation, such as radar radiation, such as radar sensors. Especially in the case of ultrsound sensors or sensors for electromagnetic radiation,

sensor axis 18 is defined by the central axis of the radiation lobe. In the preferred exemplary embodiment in the motor vehicle, nominal direction 19 in ultrasound sensors is also defined relative to the axis of travel. It is possible, for instance, to connect a plurality of sensors 13 of the same and/or various types to a support 11 via a holding element 12. This variant of the method permits the simultaneous, precise fastening and alignment of a plurality of sensors 13 via one holding element 12. The only assumption is that holding element 12 has a sensor seating surface 14, for each sensor 13, which is able to be reworked. In particular, the method described and the device make possible the fastening and the alignment of two video sensors which essentially record the same scene, especially stereo camera systems. In this context, the video sensors may be connected to support 11, either via a single holding element 12 having two sensor seating surfaces 14, or via two holding elements 12 each having one sensor seating surface 14. As the support, using convex, concave and/or flat surfaces is possible for accommodating holding element 12. Support 11 and/or holding element 12 may have component part tolerances which are compensated for by the method and the device. The alignment of sensor axis 18 of sensor 13 is as desired. Preferably, there is alignment with support 11 and holding element 12, or the opposite. Other methods than adhesion processes are possible for connecting holding element 12 to support 11. Especially in the case of supports 11 made of metal or plastic, detachable or non-detachable connections such as screws or rivets are conceivable.

In one further variant of the embodiment, holding elements 12 without accommodation 16 and/or sensor antechamber are possible. In this variant of the embodiment, sensor 13 is fastened directly to sensor seating surface 14.

If an accommodation 16 and/or a sensor antechamber 15 is present, their shape will depend on the properties of sensor 13. The shape of accommodation 16 has to be adapted to the geometrical properties of sensor 13, whereas sensor antechamber 15 has to correspond to the angular coverage of sensor 13. The geometrical properties of sensor seating surface 14 must also correspond to the sensor type, in particular, a planar or point-shaped sensor seating surface 14 may be present. The material of support 11 and/or of holding element 12 has to be partially or completely transparent to the sensor-influencing variables because of the material properties, and/or the transparency to the sensor-influencing variables is achieved by material-removing processing methods. In the exemplary embodiment, the windshield, which is made of glass, is partially transparent to light in the visible range, whereas the transparency of holding element 12 was achieved by an opening in the form of sensor antechamber 15.

In one variant of the exemplary embodiment described, the determination of the deviation of sensor axis 18 from nominal direction 19 and/or the reworking of sensor seating surface 14 are carried out during the hardening of the adhesive in the adhesion process for connecting holding element 12 to support 11. This procedure is suitable for all connections of holding element 12 to support 11 that require a longer time to reach the final fastness.

In one additional variant of the exemplary embodiment described, it is conceivable that one may change the sequence of the individual method steps. For example, it is possible first to determine the deviation of sensor axis 18 from nominal axis 19, then to rework sensor seating surface 14 on account of the ascertained deviation of sensor axis 18 from nominal direction 19, so that one may subsequently connect holding element 12 to support 11. In the last method step,

sensor 13 is finally connected to holding element 12. Alternatively, even after the reworking, fastening sensor 13 to holding element 12 and subsequently fastening holding element 12, having sensor 13, to support 11 is possible.